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Aggregate Resources Inventory Paper 8

AGGREGATE RESOURCES INVENTORY OF BRANTFORD TOWNSHIP BRANT COUNTY SOUTHERN ONTARIO

by

Staff of the Engineering and Terrain Geology Section

Ontario Geological Survey

1980

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ABSTRACT

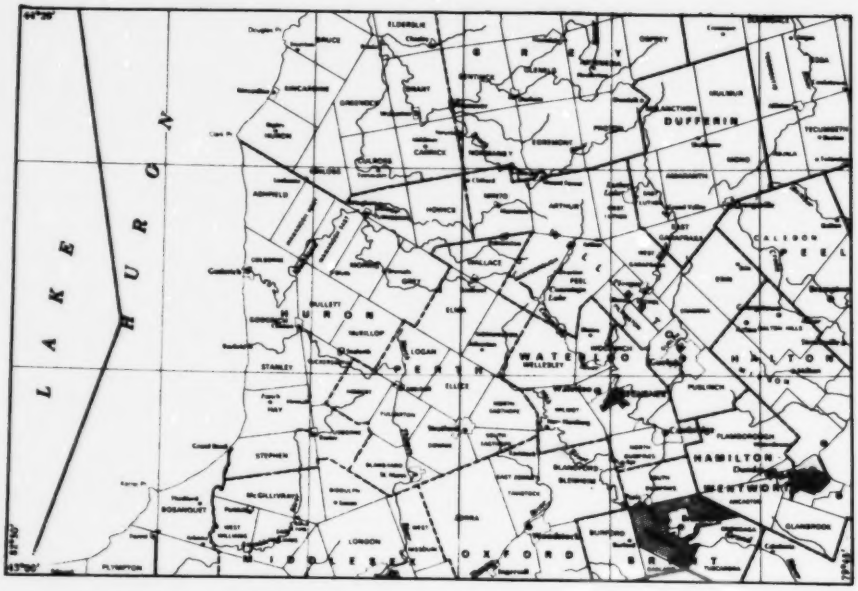


Figure: 1 - Key Map Showing Location of Brantford Township. Scale 1:1 800 000.

An inventory and evaluation of aggregate resources, which includes crushed stone derived from bedrock as well as natural sand and gravel, was completed for Brantford Township in 1979. This is part of the Aggregate Resources Inventory Program for townships and municipalities designated under The Pits and Quarries Control Act, 1971. The aggregate resources in the township have been assessed according to standards developed for the Program.

In Brantford Township, five areas containing significant amounts of sand and gravel have been selected for possible resource protection. Selected Sand and Gravel Resource Areas have an area of 5900 acres (2390 ha), exclusive of licenced areas. An estimated 4810 acres (1950 ha) are currently available for extraction, containing possible resources of approximately 325 million tons (290 million tonnes). The available portions of the Selected Areas represent 28 percent of the total area occupied by sand and gravel deposits in the township and 30 percent of the total resource tonnage.

Selected Sand and Gravel Resource Area 1, near the east bank of the Grand River, constitutes the most important natural aggregate deposit in the township. The Area contains an estimated 40 million tons (36 million tonnes) of sand and crushable gravel suitable for a wide range of road-building and construction uses.

Selected Sand and Gravel Resource Area 2, near the west bank of the Grand River, contains an estimated 77 million tons (70 million tonnes) suitable for a range of crushed products.

Selected Sand and Gravel Resource Areas 3 and 4 are portions of the outwash plain which covers much of the western portion of the township. Available resources in these two deposits are estimated to be 169 million tons (153 million tonnes).

Selected Sand and Gravel Resource Area 5, to the south of Area 2, contains 37 million tons (34 million tonnes) of material suitable for a range of crushed products.

Brantford Township is an important regional source of road-building and construction material. Care should be taken to ensure the continuing availability of as much of these resources as possible.

No bedrock resource areas have been selected in Brantford Township.

Selected Resource Areas are not intended to be permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such resource areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

AGGREGATE RESOURCES INVENTORY OF BRANTFORD TOWNSHIP

STAFF OF THE ENGINEERING
AND TERRAIN GEOLOGY SECTION

INTRODUCTION

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1976, the total tonnage of mineral aggregates extracted was greater than that of any other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Natural Resources 1977).

Although mineral aggregate deposits are plentiful in southern Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where they occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area as well as its quality and size. The potential for extractive development is usually greatest in urban fringe areas where land use competition is extreme. For these reasons the availability of adequate resources for future development is now being threatened in some areas.

Comprehensive planning and resource management strategies are required to make the best use of available resources, especially in those areas experiencing rapid development. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies and official plans. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of a municipality's resources.

The report includes an assessment of sand, gravel and crushed bedrock. The most recent information available has been used to prepare the reports. As new information becomes available, revisions may be necessary.

PART I - INVENTORY METHODS

FIELD AND OFFICE METHODS

The methods used to prepare the report primarily involve the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References). Wherever possible, field examination of potential resource areas was also undertaken to confirm interpretations made in the office. Field methods included the examination of natural and man-made exposures of granular material. Most observations were made at quarries and sand and gravel pits located from records held by the Ontario Ministry of Transportation and Communications, the Ontario Geological Survey, and by Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites included estimates of the total face height and the proportion of gravel- and sand-size fragments in the deposit. Observations were also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, test pitting, soil probing and hand-augering techniques were used to assess subsurface materials. Air photos at various scales were used to determine the continuity of deposits, especially in areas of limited subsurface information.

In the office, the pit data were supplemented by information on file with the Engineering Materials Office of the Ontario Ministry of Transportation and Communications. Data contained in these files include field estimates of the depth, composition and "workability" of deposits as well as laboratory analyses of the physical properties and chemical suitability of the aggregate. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The location, size, and depth of extraction of pits licenced under The Pits and Quarries Control Act, 1971 were obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above named groups in the compilation of inventory data is gratefully acknowledged.

Water well records, held by the Ontario Ministry of the Environment, were used in some areas to corroborate thickness estimates, or to indicate the presence of buried granular material. These records were used only in conjunction with other evidence. Topographic maps of the National Topographic System, at a scale of 1:50 000, were used as a compilation base for the field and office data. The information was then transferred to a township base map, also at a scale of 1:50 000, prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

SAND AND GRAVEL RESOURCES

Once the interpretative boundaries of the aggregate units have been drawn, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows: First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data such as water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot thick layer of sand and gravel, one acre in extent, assuming an average density of 110 pounds per cubic foot.

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 represent only those parts of the deposit lying outside licenced areas (Column 2).

Two successive subtractions are made from the unlicenced area. Column 3 accounts for the number of acres unavailable due to the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas that have previously been extracted (e.g. wayside pits are included in this category). The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage presently available for extractive development and/or resource protection.

BEDROCK RESOURCES

The method used to calculate resources of bedrock-derived aggregate is much the same as that described above. The areal extent of favourrable bedrock formations overlain by less than 50 feet (15 m) of unconsolidated overburden is determined from bedrock geology maps, drift thickness and bedrock topography maps and from the interpretation of water well records. The measured extent of such areas is then multiplied by the estimated workable thickness of the formation, based on stratigraphic analyses and on estimates of existing quarry faces in the unit. In some cases a standardized estimate of a workable thickness of 60 feet (18 m) is used. Volume estimates are then multiplied by 3600 (the estimated weight in tons of a one-foot thick section of dolostone, one acre in extent, assuming a bulk density of 165 pounds per cubic foot).

Resources of sandstone are calculated using a bulk density estimate of 146 pounds per cubic foot or approximately 3200 tons per acre. Shale resources are calculated on the basis of a bulk density estimate of 150 pounds per cubic foot.

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany the report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel as well as bedrock-derived aggregates are termed possible resources in accordance with terminology of the Ontario Resource Classification Scheme (Robertson 1975,p.7) and with the Association of Professional Engineers of Ontario (1976) (see Glossary, Appendix B).

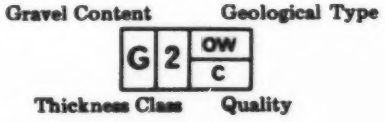
PART II - DATA PRESENTATION AND INTERPRETATION

Three maps, each portraying a different aspect of the aggregate resources in the municipality, accompany the report. Map 1, "Distribution of Sand and Gravel Deposits", gives a comprehensive inventory of the sand and gravel resources in the report area. Map 2, "Selected Sand and Gravel Resource Areas", shows those deposits which are considered to represent the largest and/or highest quality resources in the area. Map 3, "Bedrock Resources", shows the distribution of bedrock formations, the distribution of overlying unconsolidated sediments, and identifies the Selected Bedrock Resource Areas.

MAP 1: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Map 1 is derived directly from the existing surficial geology maps of the area or from air photo interpretation where surficial mapping is incomplete. It shows the extent of sand and gravel deposits within the study area and serves as a base for the calculation of the total sand and gravel resources.

Map 1 presents a summary of all available information related to the quantity and quality of aggregate contained in all the known aggregate deposits in the study area. Much of this information is contained in the symbol which identifies each deposit. The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for a given deposit. These components are illustrated by the following example:



This symbol identifies an outwash deposit 10 to 20 feet (3 to 6 m) thick containing more than 35 percent gravel. Excess fines may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate makes up less than 35 percent of the whole deposit. "G" indicates that the aggregate probably contains more than 35 percent gravel. If no information is available, the letters are omitted.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identify the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix C) and the lower series of letters identify the main quality limitations that may be present in the deposit as discussed in the next section.

The other information presented on Map 1 is designed to give an indication of the present level of extractive activity in the study area. Those areas which are licenced for extraction under The Pits and Quarries Control Act, 1971 are shown by a solid outline and identified by a number which refers to the pit descriptions in Table 2. Each description notes the owner, location and licenced acreage of the pit, as well as the estimated face height and percentage gravel. A number of unlicenced pits are also identified and numbered on Map 1 and described in Table 2.

MAP 2: SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 2 is an interpretative map derived from an evaluation of the deposits shown on Map 1. The deposits identified on Map 2 are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary, secondary, and tertiary. These areas are identified on Map 2 by different shading patterns.

Each area of primary significance is assessed as to its probable relative value as a resource in the municipality and is given a deposit number which denotes its ranking order. All such deposits are shown by a medium-grey tone on Map 2.

Selected Aggregate Resource Areas of primary significance are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such resource areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Deposits of secondary significance are not ranked numerically in this report, but are indicated by a light grey tone on Map 2. Such deposits are believed to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the "best" resource areas in a municipality, they may contain large quantities of sand and gravel and should be considered an integral component of the aggregate supply of the municipality.

Areas of tertiary significance are indicated on the map by a dashed line but have no grey tone. They are neither rated nor considered to be important resource areas because of their low available resources, or because of possible difficulties in extraction. Such areas may be useful for local needs but are unlikely to support large-scale development.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the municipality is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

DEPOSIT SIZE

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the municipality. Generally, deposits in Class 1, i.e. those thicker than 20 feet (6m) and containing more than 35 percent crushable gravel are considered to be most favourable for commercial development. Thinner deposits may be valuable in municipalities with low total resources.

AGGREGATE QUALITY

The limitations of natural aggregates for various uses result from variations in the lithology of the particles composing the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the symbol for each deposit on Map 1. They are: gravel content (G or S), fines (C), oversize (O) and lithology (L).

Three of the indicators deal with grain size distribution. The "gravel content", (G or S), indicates the suitability of aggregate for various uses. Deposits containing more than 35 percent crushable gravel are considered to be favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess "fines" or high silt and clay content may severely limit the potential use of an aggregate. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent "oversize" particles (those greater than 4 inches (10 cm) in diameter) may also have use limitations. The oversize component is unacceptable for all concrete aggregate and for road-building

aggregate, so must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

The other indicator of the quality of an aggregate is "lithology". Just as the unique physical and chemical properties of bedrock formations determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high-quality uses. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol indicates either "C", "O" or "L" or any combination, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt has been made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of the Ontario Ministry of Transportation and Communications and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations. The Engineering Materials Office of the Ontario Ministry of Transportation and Communications has recently compiled a detailed assessment of aggregate suitability for selected areas in southern Ontario. This material has been consulted extensively in preparation of the inventory reports.

LOCATION AND SETTING

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of those natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, powerlines, and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3.

The assessment of sand and gravel deposits and bedrock resource areas with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report but readers are encouraged to discuss them with personnel of the Ontario Ministry of Natural Resources' District Office.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain at roughly the same level.

The aggregate resources in the region surrounding a municipality should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, a municipality that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Municipalities with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data

or on considerations outlined in preceding sections.

MAP 3: BEDROCK RESOURCES

Map 3 is an interpretative map derived from bedrock geology, bedrock topography, drift thickness maps, water well data from the Ontario Ministry of the Environment, oil and gas well data from the Petroleum Resources Section (Ontario Ministry of Natural Resources), and from geotechnical well data from various sources. Map 3 is based on concepts similar to those outlined for Maps 1 and 2, but displays both the inventory and evaluation on the one map.

The geological boundaries of the labelled bedrock units are shown by a dashed line. Isolated outcrops are indicated by an "X". Three sets of contour lines delineate areas of less than 3 feet (1 m) of drift, areas of 3 to 25 feet (1 to 8 m) of drift, and areas of 25 to 50 feet (8 to 15 m) of drift. The extent of the areas of thin drift are shown by three tones. The darkest tone indicates areas where bedrock outcrops or is within 3 feet (1 m) of the ground surface. These areas constitute potential resource areas of primary significance due to their easy access. The medium tone indicates areas where drift cover is up to 25 feet (8 m) thick. Quarrying is possible in this depth of overburden and these also represent potential resource areas. The lightest tone indicates bedrock areas overlain by 25 to 50 feet (8 to 15 m) of overburden. These latter areas constitute resources which have extractive value only in specific circumstances. Outside of these delineated areas the bedrock can be assumed to be covered by more than 50 feet (15 m) of overburden, a depth generally considered to be too great to allow economic extraction (unless part of the overburden is composed of economically attractive sand and gravel deposits).

Other inventory information presented on Map 3 is designed to give an indication of the present level of extractive activity in the municipality. Those areas which are licenced for extraction under The Pits and Quarries Control Act, 1971 are shown by a solid outline and identified by a number which refers to the quarry descriptions in Table 5. Each description notes the owner, location, and licenced acreage of the quarry and an estimate of face height. Unlicenced quarries are also identified and numbered on Map 3 and described in Table 5. One additional symbol appears on the map: an open dot indicates the location of a selected well which penetrates bedrock. The overburden thickness is shown in feet beside the open dot.

SELECTION CRITERIA

Criteria equivalent to those used for sand and gravel deposits are used to select bedrock areas most favourable for extractive development.

The evaluation of bedrock resources is made primarily on the basis of performance and suitability data established by laboratory testing at the Ontario Ministry of Transportation and Communications. The main characteristics and uses of the bedrock formations found in southern Ontario are summarized in Appendix D.

Deposit "size" is related directly to the areal extent of thin drift cover overlying favourable bedrock formations of sufficient thickness to support quarry operations. Since vertical and lateral variations in bedrock units are much more gradual than in sand and gravel deposits, the quality and quantity of the resource is usually consistent over large areas.

Quality of the aggregate derived from specific bedrock units is established by the performance standards previously mentioned. Location and setting criteria and regional considerations are identical to those for sand and gravel deposits.

SELECTED RESOURCE AREAS

Selection of bedrock resource areas has been restricted to a single level of significance. Three factors support this approach. Quality and quantity variations are gradual. The areal extent of a given quarry operation is much smaller than that of a sand and gravel pit producing an equivalent tonnage of material. Since crushed bedrock has a higher unit value than sand and gravel, longer haul distances can be considered. These factors allow the identification of alternative sites having similar development potential. The wider range of possible resource areas allows greater flexibility in locating quarry operations away from areas of intensive land use competition. The Selected Areas are shown on Map 3 by a line pattern and the calculated available tonnages are given in Table 6.

Selected Bedrock Resource Areas shown on Map 3 are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major bedrock resource is known to exist. Such a resource area may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

PART III - ASSESSMENT OF AGGREGATE RESOURCES IN BRANTFORD TOWNSHIP

LOCATION AND POPULATION

Brantford Township occupies an area of 66,304 acres (26 833 ha) flanking the Grand River, in Brant County. The township is shown on the Brantford (40P/1) map sheet of the National Topographic System, at a scale of 1:50 000.

Population of Brantford Township was 9330 in 1978 and has been relatively stable since 1972 (Ontario Ministry of Intergovernmental Affairs 1979; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1974, 1977). The township has a large rural population, of which a significant proportion is rural-residential. The latter are concentrated in small settlements such as Mount Pleasant, Mount Vernon and Cainsville; in rural-residential developments along major roads; or in suburban developments adjacent to the City of Brantford limits.

The City of Brantford is centrally located within the township and is a regional trade, retail and industrial centre. In 1978 its population was 69,091 (Ontario Ministry of Intergovernmental Affairs 1979).

The area is well served by a network of paved and gravel-surfaced township roads, paved county roads and King's highways.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The physiography of the township and the distribution of unconsolidated sediments are the result of glacial and glaciofluvial activity which took place during the latter part of the Pleistocene Epoch (Cowan 1972). Glacial ice completely covered Ontario and advanced southwest into Ohio in the Late Wisconsinan during the Pleistocene, approximately 18,000 years ago. Glacial retreat followed the main advance and the area was water covered for a brief time during which glacial lake silt was deposited. Ice then readvanced from the southeast and covered the area, depositing a fine-grained clayey silt till.

During its eventual retreat, the ice margin halted several times building hummocky, northeast-trending, end moraines just west of Brantford Township. The ice margin again retreated to the southeast but was followed by a strong readvance, at least as far as the City of Paris where its halt is marked by a second set of hummocky, northeast-trending, end moraines. The Paris Moraine is the oldest of these and represents the outer portion of the physiographic unit known as the Horseshoe Moraine (Chapman and Putnam 1966). The Paris Moraine trends south from the City of Paris past Mount Vernon and is a gently, rolling ridge composed mainly of sandy till. These deposits have little value as mineral aggregate sources. Two younger and smaller terminal moraine ridges (the Galt and Moffat Moraines) are further east of the Paris Moraine. These moraines are generally narrow, discontinuous, till ridges mantled by lacustrine sand, as at Mount Pleasant.

Sediments transported by meltwater running off the ice margin were deposited in extensive outwash plains on the western side of the Paris and Galt Moraines throughout their extent in Brantford Township. These deposits constitute an important aggregate resource for the area.

Extensive outwash deposits along the Grand River, between Paris and Brantford and along Whitemans Creek, form part of the Grand River meltwater channel system which was formed during the retreat of the ice margin from the Paris and Galt Moraines.

As the ice margin retreated southeast, meltwater dammed against the ice margin and formed a series of extensive glacial lakes (Cowan 1972, p.38). Sediments deposited in these lakes cover most of Brantford Township. Several beach deposits which represent deposition at successive lake stages are found on the flanks of the moraines in the western part of Brantford Township. The deposits are partially deltaic in origin, deposited by water flowing along the Grand River meltwater channel. The deposits vary from 45 to 80 feet (14 to 24 m) thick in Brantford Township, and consist of moderately to well sorted, fine and silty fine sand (Cowan 1972). Although the deposits have some commercial value for low-grade uses they have not

been extracted in Brantford Township.

The eastern two-thirds of the township is mantled by thick deposits of deep water glaciolacustrine sediments which were deposited in the various lakes formed during the later stages of deglaciation. The sediments consist mainly of massive or varved silt, clay and minor sand. The deposits are thin in the south and range up to more than 100 feet (30 m) thick north of Brantford. These deposits have almost no value as aggregate sources.

Several outwash terraces along the valley of the Grand River represent postglacial deposition during and following the draining of the glacial lakes. Later postglacial erosion and sedimentation along the river has produced an extensive alluvial plain consisting of sand, gravel, silt, clay and muck. Similar processes have produced alluvial plains in several smaller streams in the area. Other postglacial processes have been restricted to gullying of glaciolacustrine deposits, especially south of Brantford, and to some limited eolian erosion and deposition.

EXTRACTIVE ACTIVITY

Brantford Township has large resources of good-quality natural aggregate and has traditionally been a major sand and gravel producer. A large proportion of these potential resources are presently in danger of sterilization by conflicting land uses. Thus, as much of the remaining resources as possible should be kept available for future extraction.

Numerous pits have been opened in the township (Table 2); most are situated in the Grand River deposits. In 1972, the township was designated under The Pits and Quarries Control Act, 1971. Following designation, a large number of pits, especially the smaller ones, were abandoned. At the writing of this report, twelve properties were licenced to operate under the Act. The properties are concentrated in the outwash deposits west of the City of Brantford. There is a total licenced area of 1397.3 acres (565.5 ha). Using the reserve calculation techniques described in the Introduction, the sand and gravel resources still available for extraction in these properties are estimated to be 35 million tons (32 million tonnes).

Production figures from licenced pits in the township have been tabulated annually since its designation. The average annual production during this period has been 1.7 million tons (1.5 million tonnes). Some additional production comes from wayside pits for which permits rather than licences are required. Permits are usually issued to the Ontario Ministry of Transportation and Communications for specific road-building contracts, or to local and county municipalities for road maintenance projects. The estimated annual production figures are compiled by Regional and District Offices of the Ontario Ministry of Natural Resources. This additional production is estimated to be 0.1 million tons (0.1 million tonnes). The combined annual production in the township is thus approximately 1.8 million tons (1.6 million tonnes).

SELECTED SAND AND GRAVEL RESOURCES

Map 1 shows the widespread occurrence of granular deposits in the western portion of Brantford Township. The total area occupied by these deposits is 17,400 acres (7000 ha) which represents 26 percent of the total area of the township. Possible resources in these deposits are approximately 1050 million tons (950 million tonnes). It must be stressed that the above figure is a comprehensive inventory of all granular materials in the township and does not represent an assessment of the viable resource base under present economic and technologic conditions. Much of the material included in the inventory estimate has low potential for use either now or in the near future.

Several areas in the township contain large amounts of sand and gravel usable for many purposes. Five areas of primary significance (Table 3) and several areas of secondary significance have been shown on Map 2. Resource management measures should be considered for the five primary deposits. The selected areas of primary significance cover 5900 acres (2390 ha) or 34 percent of the total area of aggregate deposits. Available resources are estimated to be 325 million tons (290 million tonnes), which represents approximately 30 percent of the township's total resources (Table 3). The areas selected for possible resource protection in this study correspond generally to areas identified by Cowan (1976) in an earlier study of the aggregate resources of Brantford Township.

SELECTED SAND AND GRAVEL RESOURCE AREA 1

Selected Resource Area 1 is that portion of the Grand River meltwater channel system which lies along the east bank of the Grand River in the northern portion of the township. It is the southern extension of a Selected Resource Area described in the report for South Dumfries Township.

Area 1 has long been an aggregate source in the region and material has been extracted at several places. There are eight pits presently licenced to five operators (Table 2), south of the first township concession road. Pit faces in the deposit range from 20 to 30 feet (6 to 9 m) and water well data indicate thicknesses of 17 to 85 feet (5 to 26 m). A face at Pit No. 1 (southern pit) exposes 0 to 8 feet (0 to 2 m) of lacustrine silt and sand, overlying approximately 50 feet (15 m) of poorly sorted gravel with sandier interbeds. The coarse aggregate is 65 percent gravel of which three-quarters may be crushable (Cowan 1972, p.47).

Test data from the Ontario Ministry of Transportation and Communications are incomplete for this deposit, but pits are given a moderate to high use rating and a full range of crushed aggregate products may be available (Deike 1978). Cementation of the gravel in some areas, and occasional oversize clasts may be the only quality limitations.

Resource Area 1 has an area of 930 acres (375 ha), exclusive of licenced areas. However, there is considerable residential development on the northern portion of the deposit. There is also concern associated with the floodplain of the Grand River. Deletions for setback requirements and former extractive activity leaves 530 acres (214 ha) currently available. Assuming an average deposit thickness of 30 feet (9 m), resources are estimated to be 40 million tons (36 million tonnes).

Road and rail access for local and regional transport of aggregate is very good. The location of the two rail lines, however, will limit the availability of a small proportion of the aggregate resources.

SELECTED SAND AND GRAVEL RESOURCE AREA 2

Selected Resource Area 2, on the north bank of Whitemans Creek, is a portion of the Grand River meltwater channel system. Although at least two other pits have been opened in the deposit, only one pit, operated by the Township of Brantford, is presently licenced (Pit No. 6). Faces in all pits range in height from 15 to 30 feet (5 to 10 m) and expose moderately sorted, horizontally stratified gravel and pebbly sand. The aggregate ranges from 70 percent gravel in the north to much sandier material in the south. A 12-foot (4 m) face at Pit No. 15 exposes 6 feet (2 m) of horizontally layered, well sorted, coarse sand and interlayered, poorly sorted gravel overlying a further 6 feet (2 m) of poorly sorted fine gravel. The coarse granular material is underlain by sand. The quality of the gravel is high in the northern portion of the area, but in the south the aggregate is much sandier and may not be suitable for crushing (Deike 1978).

Resource Area 2 has an area of 1370 acres (550 ha), exclusive of licenced areas. The area is sparsely populated and previous extractive activity has been minimal. Thus, the area currently available for extraction is calculated to be 1230 acres (500 ha). The thickness of the unit, as indicated by water well data, ranges from 24 to 57 feet (7 to 17 m) including the underlying sand. Assuming an average thickness of 25 feet (8 m) for only the coarse aggregate, available resources are estimated to be 77 million tons (70 million tonnes).

Road access to the area is good.

SELECTED SAND AND GRAVEL RESOURCE AREA 3

Selected Resource Area 3 forms part of the outwash plain flanking the Paris Moraine in the northwest corner of Brantford Township. Extractive activity in the area has been low. The licenced area at Pit No. 7 is the southern extension of the large property owned by Standard Aggregates in South Dumfries Township; no excavation on this property has taken place in Brantford Township. Faces in two inactive pits (Pit Nos. 32 and 33) range in height from 12

to 20 feet (4 to 6 m) and expose gravelly sand and gravel containing 40 to 75 percent stone.

Information on the quality of the aggregate is lacking, but it is likely that a range of crushed products may be produced. However, siltstone content and cementation may be a problem in some areas. Selection and sand control may be necessary in the sandy southern portions of the deposit.

Resource Area 3 has an area of 2200 acres (890 ha), exclusive of licenced areas. There has been little development in the area and former extractive activity has been minimal. The area currently available for extraction is thus calculated to be 1850 acres (750 ha). Assuming an average deposit thickness of 28 feet (8 m), available resources are estimated to be 129 million tons (117 million tonnes).

Road access via Highway 2 in the northern part of the deposit is good.

SELECTED SAND AND GRAVEL RESOURCE AREA 4

Selected Resource Area 4 is a small portion of the outwash plain deposit which extends from Burford to Scotland in Burford Township. At Mount Vernon, older ice-contact stratified sand and gravel is exposed at the surface and has been included in Area 4. This portion of the Area is being extracted by the County of Brant at Pit No. 8. Extraction has taken place in the outwash portion of Area 4 at Pit Nos. 20 and 21. Due to the depositional conditions that existed in the outwash in this area, the gravel content is quite variable and clay and silt content are high in places. Deike (1978) indicates that the material is suitable only for road sub-base aggregate.

Resource Area 4 has an area of 710 acres (290 ha), exclusive of licenced areas. Cultural constraints and former extractive activity reduce the area currently available for extraction to 600 acres (243 ha). Assuming an average deposit thickness of 27 feet (8 m), available resources are 40 million tons (36 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 5

Resource Area 5 is the southern portion of the Whitemans Creek segment of the meltwater channel deposit. The material is similar in texture, composition and quality to Selected Resource Area 2.

Area 5 has an area of 690 acres (280 ha). Cultural constraints and former extractive activity reduce the area currently available to 600 acres (243 ha). Assuming an average deposit thickness of 25 feet (8 m), possible resources of sand and gravel are estimated to be 37 million tons (34 million tonnes).

SAND AND GRAVEL RESOURCES OF SECONDARY SIGNIFICANCE

Resource areas of secondary significance for resource management are shown by a light tone on Map 2. They contain good-quality aggregate and are important possible resources.

The river terrace west of Brantford is a late glacial outwash deposit and has been mapped as alluvium by Cowan (1972). A 20-foot (6m) face at Pit No. 24 exposes 7 feet (2m) of poorly sorted coarse gravel (90 percent gravel, 10 percent sand). Much of the deposit may now be depleted. Much of the area is under control of the Grand River Conservation Authority.

The deposit, which forms part of the Galt Moraine along the southern border of Brantford Township, contains moderate reserves of low-quality aggregate suitable for road sub-base course and fill.

BEDROCK GEOLOGY

Brantford Township is underlain by Silurian dolostones and shales of the Guelph and Salina Formations (Caley 1941; Telford 1979). Each unit occurs in a wide band trending roughly northeast and dipping gently to the southwest. The bedrock surface is smooth to rolling. The thickness of the unconsolidated sediments overlying the bedrock varies considerably through the township, but is generally greater than 50 feet (15 m) and is often 100 to 150 feet (30 to 46 m) thick. Bedrock is at or near the ground surface in only one area along the valley of the Grand River and Whitemans Creek, south of Paris (Map 3).

The Guelph Formation underlies the northeast portion of the township. The formation consists

of massive-to thick-bedded, fine-to medium-crystalline, light brown dolostone. Porous, high purity, reefal facies rock is common throughout the unit. The formation is generally soft and nonresistant to abrasion or to chemical weathering processes. It is not generally suitable for production of road-building or construction aggregates. Drift cover over the Guelph Formation is greater than 50 feet (15 m). Consequently, there are no areas with good potential for extractive development.

The Guelph Formation is overlain by the Salina Formation which occurs throughout the township west of Brantford. The unit consists mainly of grey shale and thin-to medium-bedded dolostone with numerous seams and lenses of gypsum. Drift cover is generally greater than 50 feet (15 m) except in the valley of the Grand River, south of Paris, where it outcrops in limited areas. The Salina is not suitable for production of crushed aggregate.

SUMMARY

Brantford Township has possible sand and gravel resources of approximately 325 million tons (290 million tonnes). These resources are an important regional source of road-building and construction material. Care should be taken to ensure the continuing availability of as much of these resources as possible.

No bedrock resource areas have been selected in the township.

Enquiries regarding the Aggregate Resources Inventory of Brantford Township should be directed to the Ontario Ministry of Natural Resources at the Cambridge District Office, Beaverdale Road, Cambridge, Ontario, N3C 2V3 (tel. (519) 658-9356) or at the Central Region Office, 10670 Yonge Street, Richmond Hill, Ontario, L4C 3C9, (tel. (416) 884-9203).

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, BRANTFORD TOWNSHIP*

1 CLASS NO.	2 DEPOSIT TYPE (See Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
1	G-OW	7200 (2900)	600 (540)
	S-LP	4600 (1860)	230 (209)
2	G-OW	75 (30)	4 (4)
	G-AL	730 (295)	27 (24)
	G-LB	17 (7)	<1 (<1)
	G-K	365 (148)	14 (13)
	S-OW	295 (119)	10 (9)
	S-LP	2100 (850)	126 (114)
3	G-OW	135 (55)	3 (3)
	G-LB	8 (3)	<1 (<1)
	G-AL	850 (345)	17 (15)
	S-OW	155 (63)	2 (2)
	S-LP	870 (350)	17 (15)
		17,400 (7000)	1050 (950)

* Identified deposit areas within the City of Brantford are omitted on all tables.

TABLE 2 | SAND AND GRAVEL PITS, BRANTFORD TOWNSHIP

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREAS Acres (Hectares)	7 FACE HEIGHT Feet (Metres)	8 % GRAVEL
LICENCED PITS							
1	B13-17 B13-95 B13-29	T. C. G. Materials	16-18 16-22	2 3	420.0 (170.0)	20-30 (6-9)	85
2	B13-24	Township of Brantford	18	2	47.2 (19.1)	20-25 (6-8)	
3	B13-35	City of Brantford	19	2	70.0 (28.3)	14 (4)	
4	B13-39	T. C. G. Materials	20	2	80.0 (32.4)		
5	B13-76	Flintkote	19-23	2	307.0 (124.2)	25 (8)	85
6	-	Township of Brantford	11	3	9.4 (3.8)	30 (9)	
7	-	Standard Aggregates	5-7	1	180.6 (73.1)		
8	B13-14	County of Brant	3, 4	4	7.9 (3.2)	35 (11)	
9	B13-6	Township of Brantford	7	2 R.W.M.P.R	13.0 (5.3)	25 (8)	
10	B13-115	Standard Aggregates	13	5	72.6 (29.4)	20-25 (6-8)	60
11	B13-42	T. C. G. Materials	1-4	Kerr Tract	94.6 (38.3)		
12	-	T. C. G. Materials	14-17	1	95.0 (38.4)	20-30 (6-9)	
					1397.3 (565.5)		
UNLICENCED PITS							
13	B13-136	T. C. G. Materials	17	1	-	10-20 (3-6)	35-75
14	B13-70	Paris City	13	1	-	20 (6)	60
15	B13-20	Peart No. 2	10, 11	2	-	10 (3)	35

TABLE 2 | SAND AND GRAVEL PITS, BRANTFORD TOWNSHIP

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREAS Acres (Hectares)	7 FACE HEIGHT Feet (Metres)	8 % GRAVEL
16	B13-118	Zelinksi	13	3	-		60
17	B13-117	Five Oaks United Church	13	3	-	10-20 (3-6)	70
18	B13-82	Peart No. 1	11	3	-	40-50 (12-15)	20-25
19	B13-19	S. Harris	11	3	-	20-30 (6-9)	
20	B13-86	Curtis No. 1	2-3	5	-	10 (3)	45-75
21	B13-87	Curtis No. 2	2-3	5	-	10 (3)	40-75
22	B13-5	Van Valkenburg	5	Kerr Tract	-	18 (6)	
23	B13-10	B. Miller	2	3	-	12 (4)	
24	B13-10	Cayuga Quarries Ltd.	23	3	-		
25	B13-11	Neil Young	3, 4	4	-		20-30
26	B13-43	M.T.C.R.O.W.	13-15	2	-	10 (3)	
27	B13-116	T. C. G. Materials (Grisenthwaite)	15	2	-	10 (3)	70
28	B13-80	Six Nations Indian Reserve			-	10-15 (3-5)	35-55
29	B13-12	Kirby	35, 36	5			40
30	B13-47	Paterson	1	Kerr Tract	-	10-15 (3-5)	15-60
31	B13-130	Keczon	4, 5	6	-	20 (6)	10-70
32	-	D. Albin	2	2	-	12 (4)	40
33	-	F. McKinnon	2	1	-	20 (6)	75

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, BRANTFORD TOWNSHIP

1	2	3	4	5	6	7
DEPOSIT NO.	**UNLICENCED AREA** Acres (Hectares)	**CULTURAL SETBACKS** Acres (Hectares)	**EXTRACTED AREA** Acres (Hectares)	**AVAILABLE AREA** Acres (Hectares)	**ESTIMATED DEPOSIT THICKNESS** Feet (Metres)	**AVAILABLE AGGREGATE** Millions of Tons (Tonnes)
1	930 (375)	220 (89)	180 (73)	530 (214)	30 (9)	40 (36)
2	1370 (550)	140 (57)	10 (4)	1230 (500)	25 (8)	77 (70)
3	2200 (890)	340 (138)	10 (4)	1850 (750)	28 (8)	129 (117)
4	710 (290)	100 (40)	10 (4)	600 (243)	27 (8)	40 (36)
5	690 (280)	88 (36)	2 (1)	600 (243)	25 (8)	37 (34)
	5900 (2390)	888 (360)	212 (86)	4810 (1950)		323 (290)

TABLE 4 | TOTAL IDENTIFIED BEDROCK RESOURCES, BRANTFORD TOWNSHIP

1 **DRIFT THICKNESS** Feet (Metres)	2 **FORMATION**	3 **WORKABLE THICKNESS** Feet (Metres)	4 **AREAL EXTENT** Acres (Hectares)	5 **ORIGINAL TONNAGE** Millions of Tons (Tonnes)
0-3 (0-1)	Salina	60 (18)	180 (73)	35 (32)
3-25 (1-8)	Salina	60 (18)	780 (320)	150 (136)
25-50 (8-15)	Salina	60 (18)	1380 (560)	265 (240)
			2340 (950)	450 (410)

TABLE 5 QUARRIES, BRANTFORD TOWNSHIP

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREA Acres (Hectares)	7 FACE HEIGHT Feet (Metres)

–NONE–

TABLE 6 | SELECTED BEDROCK RESOURCE AREAS, BRANTFORD TOWNSHIP

1 DEPOSIT NO.	2 DEPTH OF OVERBURDEN Feet (Metres)	3 UNLICENCED AREA Acres (Hectares)	4 CULTURAL SETBACKS Acres (Hectares)	5 EXTRACTED AREA Acres (Hectares)	6 AVAILABLE AREA Acres (Hectares)	7 ESTIMATED WORKABLE THICKNESS Feet (Metres)	8 AVAILABLE TONNAGE Millions of Tons (Tonnes)

- NONE -

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APPENDIX B-GLOSSARY

ABRASION RESISTANCE

Tests such as the Los Angeles Abrasion Test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

ABSORPTION CAPACITY

Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

AGGREGATE

Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

CAMBRIAN

The first Period of the Paleozoic Era, thought to have covered the time between 570 and 500 million years ago; the Cambrian precedes the Ordovician Period.

CLAST

An individual constituent, grain, or fragment of a sediment or rock, produced by the mechanical weathering of a larger rock mass. Synonyms include particle and fragment.

DELETERIOUS LITHOLOGY

A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone, and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

DEVONIAN

A Period of the geological past thought to have covered the span of time between 395 and 345 million years ago, following the Silurian Period. Rocks formed in the Devonian Period are among the youngest found in Ontario.

DIRT

See fines.

DOLOSTONE

A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

DRIFT

A general term for all unconsolidated rock debris transported from one place and deposited in another; distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

DRUMLIN

A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were deposited beneath an advancing ice sheet, and were shaped by its flow.

EOLIAN

Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

FINES

A general term used to describe the size fraction of an aggregate which passes (is finer than) the No.200 mesh screen (0.074 mm). Also described informally as "dirt", these particles are in the silt- and clay-size range.

GLACIAL LOBE

A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced and retreated numerous times during the Pleistocene, producing the complex arrangement of glacial material and landforms found in southern Ontario.

GRADATION

The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulder		>-256 mm
Gravel	cobble	64-256 mm
Gravel	pebble	4-64 mm
Gravel	granule	2-4 mm
Sand	coarse	.5-2 mm
	medium	.25-.5 mm
	fine	.074-.25 mm
Silt, clay		<.074 mm

GRANULAR BASE COURSE

Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability, and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

H.L. (HOT-LAID OR ASPHALTIC AGGREGATE)

Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (H.L. 1, 3, and 4), or as binder course (H.L. 2, 6, and 8) used to bind the surface course to the underlying granular base course.

LITHOLOGY

The description of rocks on the basis of such characteristics as color, structure, mineralogic composition, and grain size. Generally, the description of the physical character of a rock.

MELTWATER CHANNEL

A drainage way, usually terraced, produced by water flowing away from a melting glacier margin.

ORDOVICIAN

An early period of the Paleozoic Era thought to have covered the span of time between 500 and 435 million years ago.

PALEOZOIC ERA

One of the major divisions of the geologic time scale thought to have covered the time between 570 and 230 million years ago. The Paleozoic Era (or Ancient Life Era) is subdivided into six geologic Periods, of which only four (Cambrian, Ordovician, Silurian, and Devonian) can be recognized in southern Ontario.

PLEISTOCENE

An Epoch of the recent geological past including the time from approximately 1.8 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity.

POSSIBLE RESOURCE

Reserves estimates based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

SHALE

A fine-grained, sedimentary rock formed by the consolidation of clay, silt, or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone, and mudstone.

SILURAIN

An early Period of the Paleozoic Era thought to have covered the time between 435 and 395 million years ago. The Silurian follows the Ordovician Period and precedes the Devonian Period.

SOUNDNESS

The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

TILL

Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

WISCONSINAN

Pertaining to the last glacial stage of the Pleistocene Epoch in North America. It began approximately 85,000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of southern Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

APPENDIX C-GEOLOGY OF SAND AND GRAVEL DEPOSITS

The type, distribution, and extent of sand and gravel deposits in southern Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 7000 to 85 000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and they can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

ICE-CONTACT TERRACES (ICT)

These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley, The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous due to extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive due to the variability of the deposits both in terms of quality and grain-size distribution.

KAMES (K)

Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits producing internal structures characterized by bedding discontinuities. The deposits consist mainly of irregularly bedded and cross-bedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good-quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the rare presence of excess fines (silt-and clay-sized particles).

ESKERS (E)

Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. They vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout southern Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

UNDIFFERENTIATED ICE-CONTACT STRATIFIED DRIFT (IC)

This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits due to their lack of continuity and grain-size variability. They are given a qualitative

rating based on existing pit and other subsurface data.

OUTWASH (OW)

Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. They occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain-size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

ALLUVIUM (AL)

Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and it has generally low value due to the presence of excess silt- and clay-sized material. There are no large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

GLACIOLACUSTRINE BEACH DEPOSITS (LB)

These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of southern Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the underlying material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

GLACIOLACUSTRINE DELTAS (LD)

These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In southern Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

GLACIOLACUSTRINE PLAIN (LP)

The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources due to their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

END MORAINES (EM)

These are belts of glacial drift deposited at, and parallel to, glacier margins. They commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best resource areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

WINDBLOWN FORMS (WD)

Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in southern Ontario are derived from,

and deposited on , pre-existing lacustrine sand plain deposits. Windblown sediments are almost invariably composed of fine to coarse sand and are usually well sorted. The probability of locating crushable aggregate in windblown deposits is very low.

APPENDIX D-GEOLOGY OF BEDROCK DEPOSITS

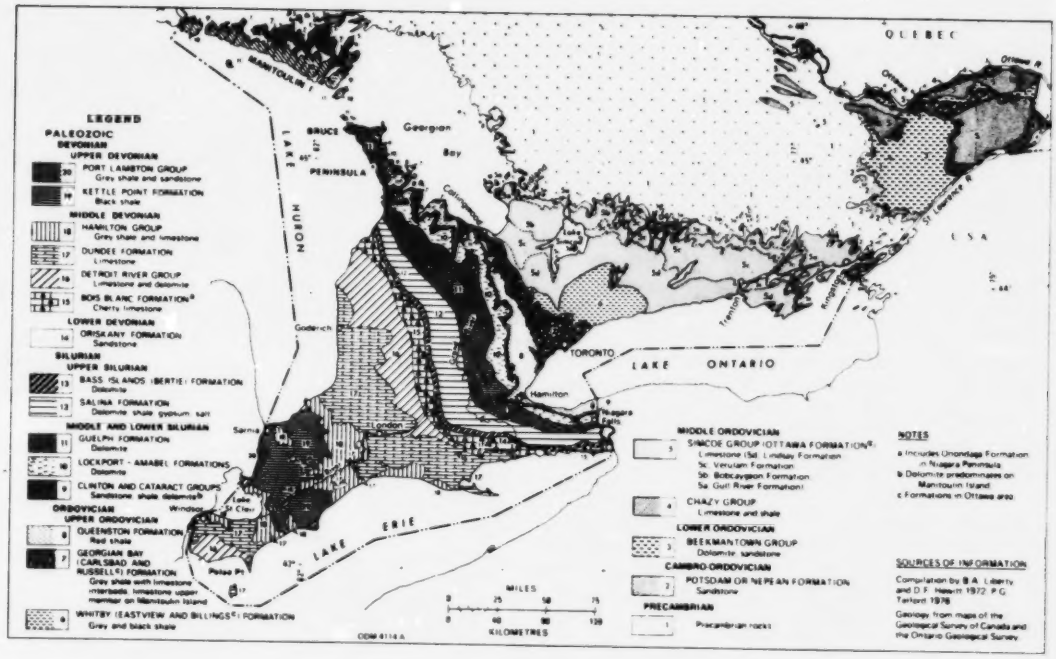


Figure 2 - Bedrock Geology of Southern Ontario

BEDROCK SUITABLE FOR CRUSHED STONE PRODUCTS

BASS ISLANDS FORMATION (UPPER SILURIAN)

(Includes the Bertie Formation of the Niagara Peninsula) Composition: Medium- to massive-bedded, aphanitic, brown dolostone with shaly partings. Thickness: 35 to 60 feet (11-18m) near Hagersville. Uses: Quarried for crushed stone on the Niagara Peninsula at Fort Erie, Cayuga, Hagersville, and Dunville. Los Angeles Abrasion Test: 17-35% loss; Absorption: 1.4%. Shaly parts are unsuitable for aggregate due to high soundness losses.

BOBCAYGEON FORMATION (MIDDLE ORDOVICIAN)

Composition: Compact, homogeneous, medium- to thin-bedded, fine-grained limestone with some argillaceous and shaly partings. Thickness: The lower unit is 40 to 72 feet (12 to 22 m) thick in the east and the remainder of the formation is 40 feet (12 m). Uses: Quarried at Kirkfield and Marysville for crushed stone. The Bobcaygeon Formation has consistently acceptable quality for granular base course materials and concrete.

BOIS BLANC FORMATION (LOWER-MIDDLE DEVONIAN)

Composition: Brownish grey, medium-crystalline, medium- to thin-bedded, cherty limestone, commonly fossiliferous. Limestone may be silty or sandy in places. Thickness: 9 to 200 feet (3 to 61 m). Uses: Quarried at Hagersville, Cayuga, and Port Colborne for crushed stone. High chert content makes much of the material unsuitable for concrete aggregate. Los Angeles Abrasion

Test: 14-28% loss; Soundness Test: 4-10% loss; Absorption: 0.7-2.0%.

DUNDEE FORMATION (MIDDLE DEVONIAN)

Composition: Fine- to medium-crystalline, brown ish grey, medium- to thick-bedded, dolomitic limestone with shaly partings, sandy layers, and chert in some areas. Thickness: 60 to 160 feet (18 to 49 m). Uses: Quarried near Port Dover and Pelee Island for crushed stone. Used at St. Marys for portland cement. Los Angeles Abrasion Test: 22-32% loss; Absorption: 0-4%.

GULL RIVER FORMATION (MIDDLE ORDOVICIAN)

Composition: Member A: thin-to thick-bedded, interbedded, grey argillaceous limestone and buff to green dolostone with a maximum thickness of 60 feet (18 m). Members B and C are dense, aphanitic limestones with argillaceous dolostone interbeds. Uses: Quarried at Kirkfield, Victoria County, and Uthoff for crushed stone. The product is generally fresh and compact with good cubic-shaped factor, low clay content, low absorption, and low soundness losses. Smooth particle surfaces may cause adhesion problems for asphalt. There is some alkali reactivity in a few of the layers.

LOCKPORT AND AMABEL FORMATIONS (MIDDLE SILURIAN)

Composition: Amabel Formation (Georgetown to the Bruce Peninsula): massive, fine crystalline dolostone, with reef facies dolostone near Georgetown. Lockport Formation (lateral facies equivalent to the Amabel Formation from Georgetown to Niagara Falls): thin- to massive-bedded, fine- to medium-grained dolostone. Thickness: Amabel Formation: maximum observed thickness of 84 feet (26 m). Lockport Formation: up to 130 feet (40 m). Uses: The Lockport and Amabel Formations have been used to produce lime, crushed stone, and building stone throughout their area of occurrence, and are a valuable aggregate resource. Los Angeles Abrasion Test: 21-35% loss; Soundness Test: 2.0% loss; Absorption: 0.4-1.6%.

ONONDAGA FORMATION (MIDDLE DEVONIAN)

(Equivalent to the Detroit River Group, with a textural change) Composition: Edgecliffe Member: medium-bedded, fine- to medium-grained, dark grey cherty limestone with an estimated thickness of 25 to 30 feet (8 to 9 m). Clarence Member: massive-bedded, dark grey brown, fine-grained, very cherty limestone having an estimated thickness of 26 feet (8 m). Moorehouse Member: medium-bedded, dark grey brown or purplish brown, fine- to coarse-grained, variably cherty limestone with an estimated thickness of 15 to 25 feet (5 to 8 m). Uses: Quarried for crushed stone on the Niagara Peninsula at Welland and Port Colborne. High chert content makes much of the material unsuitable for concrete aggregate.

OTTAWA FORMATION (MIDDLE ORDOVICIAN)

Composition: Lower Phase (Lowville and Pamela Beds): shale, some sandstone and dolostone. Thickness: 100 feet (30 m). Middle Phase (Hull, Rockland, and Leray Beds): pure, thick-bedded, crystalline limestone. Thickness: 150 feet (46 m) near Ottawa. Upper Phase (Cobourg and Sherman Fall Beds): pure and impure crystalline limestone with few to numerous shaly partings, 450 to 475 feet (137–145 m) thick near Ottawa. Uses: The Leray, Rockland, and Hull Beds have been quarried extensively for crushed stone and for building stone. In addition, the Hull Beds are an excellent source of lime for cement production and agricultural uses.

OXFORD FORMATION (LOWER ORDOVICIAN)

Composition: Medium- to thick-bedded, grey dolostone, with some shaly partings. Thickness: 240 feet (73 m). Uses: Quarried for crushed stone (road and concrete aggregate) at Ottawa, Brockville, and Smiths Falls.

BEDROCK SUITABLE FOR LIME PRODUCTION AND OTHER CHEMICAL USES.

DETROIT RIVER GROUP (MIDDLE DEVONIAN)

(Equivalent to the Onondaga Formation in the Niagara Peninsula, with a textural change). Composition: Near Beachville, the group consists of medium- to micro-crystalline, medium-bedded, high purity limestone. It grades northwards near St. Marys to soft, evenly bedded, fine-grained dolostone with bituminous laminae. Massive, porous, reef facies material also occurs to the north (Formosa Reef Limestone). Thickness: 100 feet (30 m) at Beachville, 350 feet (107 m) at Clinton. Uses: The most important

source of high purity limestone in Ontario is the Lucas Formation of the Detroit River Group at Beachville. Detroit River limestone produces 80% of Ontario's cement. Its dolomitic reefal facies is also important for lime production to the north. It is generally unsuitable for crushed stone. The Anderdon Member of the Lucas Formation is quarried at Amherstburg for crushed stone.

GRENVILLE MARBLE (PRECAMBRIAN)

Composition: Recrystallized white limestone and dolostone, fine- to coarse-grained, usually of high chemical purity. Uses: Lime production, but also in small amounts for terrazo chips, poultry grit, decorative stone, and building stone.

GUELPH FORMATION (MIDDLE SILURIAN)

Composition: Aphanitic- to medium-crystalline, thick-bedded, soft, porous dolostone, characterized in places by extensive vuggy, porous reefal facies dolostone of high chemical purity. The Guelph Formation and the underlying Amabel Formation have a combined thickness of 200 feet (61 m) on the Niagara Peninsula and more than 400 feet (122 m) on the Bruce Peninsula. Uses: The main use is for dolomitic lime in the construction industry. It is quarried at Glen Christie and Guelph.

LINDSAY FORMATION (MIDDLE ORDOVICIAN)

Composition: Lower Member: fine-crystalline, rubbly, nodular, weathering limestone. Upper Member: grey calcareous claystone with shaly partings and bioclastic layers. The rock is "soft" and weathers to rubble. Both members are characterized by low dolomite content and by numerous clayey partings. Uses: Quarried at Picton, Ogden Point, Colborne, and Bowmanville for lime. It is generally unsuitable for crushed stone, concrete aggregate, or granular base course.

VERULAM FORMATION (MIDDLE ORDOVICIAN)

Composition: Fossiliferous, pure to argillaceous limestone and interbedded calcareous shale. The rock is not resistant to erosion and commonly weathers to rubble. Thickness: 200-300 feet (61-91 m). Uses: Quarried at Picton, Ogden Point, and Mara Township for lime. It is unsuitable for crushed stone due to clay impurities and many clayey interbeds, low abrasion resistance, high soundness losses and poor freeze-thaw resistance.

BEDROCK SUITABLE FOR BRICK AND TILE MANUFACTURE

GEORGIAN BAY FORMATION (UPPER ORDOVICIAN)

(Formerly known as the Meaford-Dundas and Blue Mountain shales in the Toronto and Bruce Peninsula areas). Composition: Soft, fissile, blue grey shale with limey or sandy lenses in a few places. Thickness: 640 feet (195 m) at Toronto. Uses: Five producers in Metro Toronto and Cooksville produce brick and structural tile (Guillet 1967). Lightweight aggregate is also produced at Streetsville by heat expansion of the shale.

HAMILTON GROUP (MIDDLE DEVONIAN)

Composition: Grey shale with interbeds of crystalline and cherty limestone. The Group has six formations. Only the Arkona is of commercial value. It is a soft, light grey, calcareous shale which is plastic and easily worked when wet. Thickness: 80 to 300 feet (24 to 91 m). Uses: The Arkona Formation is extracted at Thedford and near Arkona for production of drainage tile and brick.

QUEENSTON FORMATION (UPPER ORDOVICIAN)

Composition: Red, thin- to thick-bedded, sandy to argillaceous shale with green mottling and banding. Thickness: 400 to 500 feet (122 to 152 m). Uses: There are 12 large shale quarries developed in the Queenston Formation in the Toronto-Hamilton region and one at Russell, near Ottawa (Guillet 1967). All produce brick for construction. The Queenston Formation is the most important source material for brick manufacture in the Province.

BEDROCK SUITABLE FOR OTHER INDUSTRIAL PRODUCTS

NEPEAN (POTSDAM) FORMATION (CAMBRO-ORDOVICIAN)

Composition: Creamy, coarse-grained, silica sandstone. Uses: Quarried throughout its area of outcrop for building stone, decorative stone, abrasives, and for glass making.

SALINA FORMATION (UPPER SILURIAN)

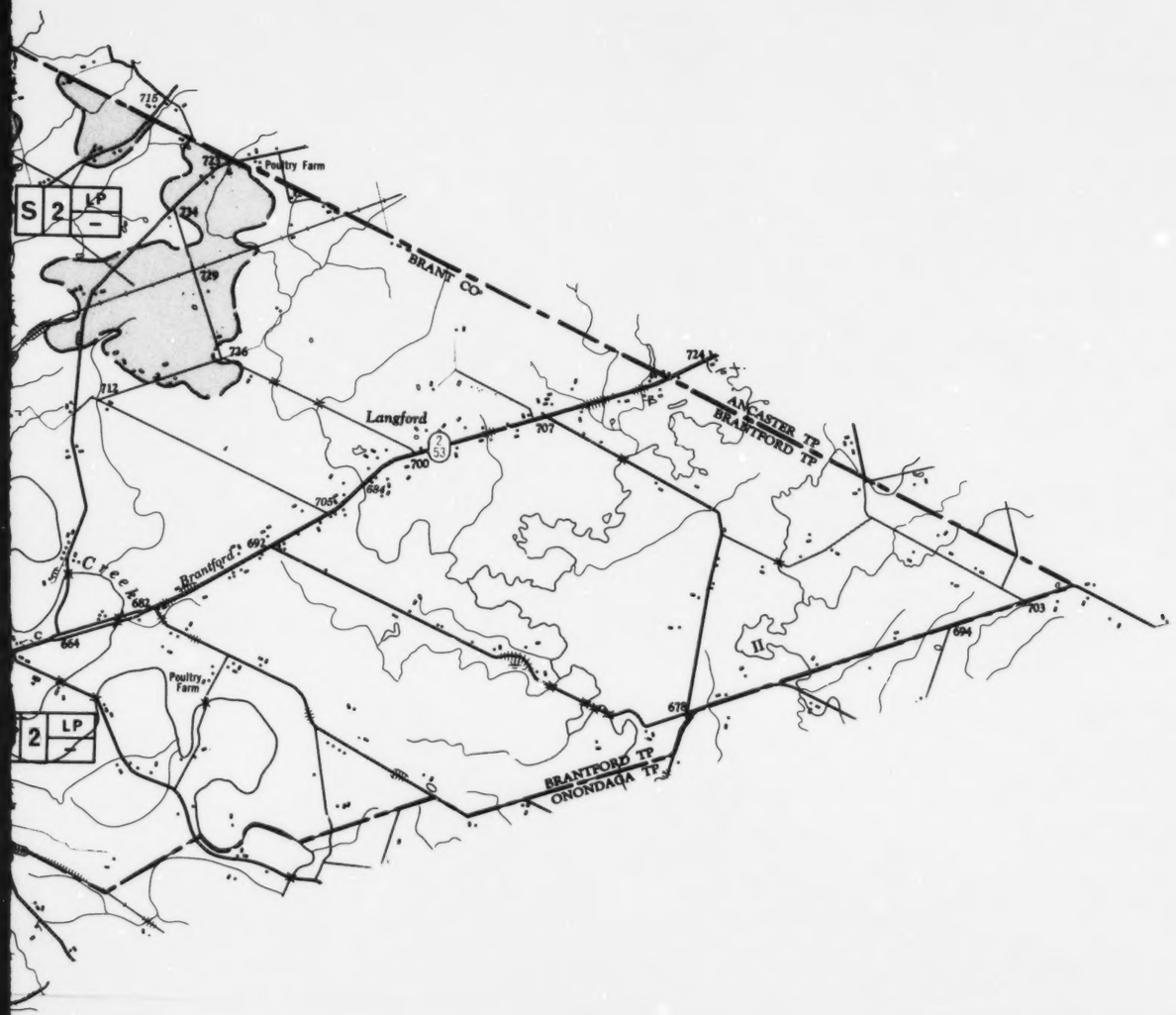
Composition: Grey and red shale, brown dolomite, and, in places, salt, anhydrite, and gypsum. The formation consists predominantly of evaporite deposits with up to eight members identified. Uses: Gypsum is mined at Hagersville, Caledonia, and Drumbo. Salt is mined at Goderich and is produced from brine wells at Amhertsburg, Windsor, and Sarnia.

WHITBY FORMATION (UPPER ORDOVICIAN)

(Formerly known as Collingwood Shale near Toronto). Composition: Brown to black fissile shale. Uses: Quarried at Bowmanville for use in cement production. Testing indicates that the Whitby Formation may produce satisfactory lightweight expanded aggretage.

G 3 OW –
G 3 AL –
G 1 OW –
G 3 AL C
G 1 OW –
S 1 LP C
G 1 OW –
S 3 LP C
S 3 LP –
S 1 LP –
S 3 LP –
S 2 LP C
G 1 OW L
G 2 K –
S 3 LP –
G 3 OW –
S 2 LP –
G 3 AL C
G 1 OW –
G 3 AL –
G 1 OW O
G 2 AL C
G 2 LB –
G 2 OW C
S 3 LP –
S 3 LP C
G 3 LB –
S 1 LP C
G 1 OW –
G 2 AL –
G 3 AL C
G 2 K –
G 2 OW –
G 2 C
G 2 AL C
Falkland
Bishopgate
Mount Vernon
PARIS
BRANTFORD
WEST BRANTFORD
SOUTH DUMFRIES TP
BRANTFORD TP
Osborne Corners
Orchard Road
Orchard Governors
Brantford Golf and Country Club
Wyndham Hills Golf Course
Golf Course
Golf and Country Club
Sports Track
Trans Station
Transformer Station
Radio Towers
Poultry Farm
Orchards
Silos
Campsite
Gravel Pits
Brick Yard
Abattoir
Pumping Station
Underground Res
Cemetery
Sawmill
Fur Farm
Auto Wrecker
Golf Course
Transformer Station
Trans Station
Radio 150
Chy 135
Chy 175
Chy 150
Chy 138
Mohawk
Dump
Sewage Plant
Hosp
Historic Site
Pumping Sta
Park
Factory
Factories
Water
Theatre
Golf Course
Golf Course
Golf Course

SOUTH DUMFRIES TP
BRANTFORD TP
Orchard Road
Osborne Corners
S 1 LP –
S 3 LP –
S 2 LP –
S 2 LP C
G 2 C
G 2 AL C
S 3 LP C
S 2 LP –
Fairchild Pl
Poultry Farm
Orchard
Trans Station
Silos
Orchards
Sports Track
Radio Towers
Golf Course
Southern Hills
Langford
BRANT CO
ANCASTER TP
BRANTFORD TP
BRANTFORD
Transformer Station
ECHO PLACE
Chinaville
Auto Wrecker
Brantford Creek
BRANTFORD TP
ONONDAGA TP
OXBOW
THE
Cemetery
Sawmill
Pumping Sta
Mohawk
Dump
Sewage Plant
Historic Site
IR 40
IR 40B
Geological and deposit area.
Deposit symbol
Licenced prop
Unlicenced sand
Selected drilling overlying report



Ministry of Natural Resources

Hon. James A.C. Auld
Minister

Dr. J.K. Reynolds
Deputy Minister

Ontario

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

BRANTFORD TOWNSHIP

BRANT COUNTY

MAP 1
DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Scale: 1:50,000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference. 40 P/1

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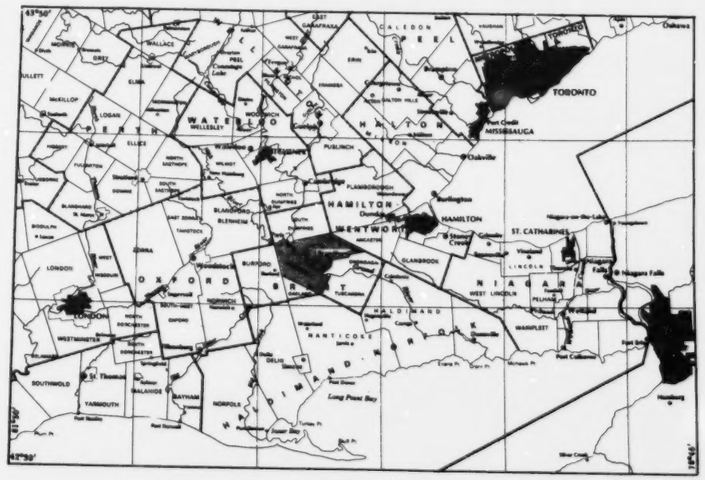


SYMBOLS

- Geological and aggregate thickness boundary. Shading indicates deposit area.
- S1 LC CLO — Deposit symbol: see below.
- 3 — Licenced property boundary; Property number: see Table 2.
- 4 — Unlicenced sand or gravel pit; Property number: See Table 2.
- 6/25 — Selected drilling location indicating thickness of overburden overlying reported thickness of granular materials (in feet). (Note: S-sand, G-gravel, C-clay, T-till)

Thickness Class

Class	Average Thickness in feet (metres)	Tons per acre (Tonnes per hectare)
1	greater than 20 (> 6)	greater than 50,000 (> 18 500)
2	10-20 (3-6)	25,000-50,000 (9 000-18 500)
3	5-10 (1.5-3)	12,500-25,000 (4 500-9 000)

WEST BRANTFORD

Mount Pleasant

Burtch

Bishopgate

Mount Vernon

Neoport

Abandoned Airfield

Radio Towers

Auto Wrecker

BRANTFORD TP

OAKLAND TP

TUSCARORA TP

THE OXBOW

BRANTFORD

SYMBOLS

- Geological and aggregate thickness boundary. deposit area.
- S 1 IC CLO — Deposit symbol: see below.
- 3 — Licenced property boundary; Property numb
- 4 — Unlicenced sand or gravel pit; Property numbe
- 6/23 — Selected drilling location indicating thickne overlying reported thickness of granular ma (Note: S-sand, G-gravel, C-clay, T-till)
- Municipal boundary.

DEPOSIT SYMBOL

Deposits are identified by gravel content, thickness class, quality indicators. Gravel content is expressed as percent material. Classes are based on potential aggregate tonnage designated numerically. Type refers to geologic origin. indicate variations in grain size distribution and lithology.

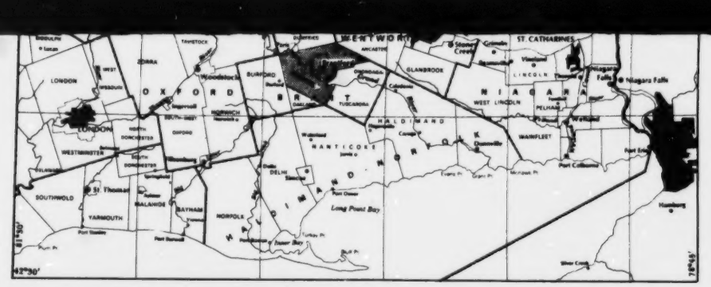
Gravel Content	Thickness Class	Geological
		Quality Ind

Gravel Content

G	Greater than 35% gravel.
S	Less than 35% gravel.
?	Requires investigation

SOU

Base map by Surveys and Mapping Branch, Ontario M Natural Resources.
Licence data from District and Regional Offices, Ontari of Natural Resources.
Aggregate suitability data from the Engineering Materia Ontario Ministry of Transportation and Communications.
Selected drilling data from the Ontario Ministry of the En and the Petroleum Resources Section, Ontario Ministry Resources.



SYMBOLS

Geological and aggregate thickness boundary. Shading indicates deposit area.

Deposit symbol: see below.

Licenced property boundary; Property number: see Table 2.

Unlicenced sand or gravel pit; Property number: See Table 2.

Selected drilling location indicating thickness of overburden overlying reported thickness of granular materials (in feet). (Note: S-sand, G-gravel, C-clay, T-till)

Municipal boundary.

DEPOSIT SYMBOL

Deposits are identified by gravel content, thickness class, deposit type and quality indicators. Gravel content is expressed as percentage of crushable material. Classes are based on potential aggregate tonnage per acre and are designated numerically. Type refers to geologic origin. Quality modifiers indicate variations in grain size distribution and lithology.

Gravel Content	Thickness Class	Geological Type
		Quality Indicators

Gravel Content

G	Greater than 35% gravel.
S	Less than 35% gravel.
?	Requires investigation

Thickness Class

Class	Average Thickness in feet (metres)	Tons per acre (Tonnes per hectare)
1	greater than 20 (> 6)	greater than 50,000 (> 18 500)
2	10-20 (3-6)	25,000-50,000 (9 000-18 500)
3	5-10 (1.5-3)	12,500-25,000 (4 500-9 000)
4	less than 5 (< 1.5)	less than 12,500 (< 4 500)

Geological Type

IC	Undifferentiated Ice-Contact Stratified Drift	OW	Outwash
ICT	Ice-Contact Terrace	LB	Lacustrine Beach
K	Kame	LP	Lacustrine Plain
E	Esker	LD	Lacustrine Delta
EM	End Moraine	AL	Older Alluvium
		WD	Windblown Forms

(see Appendix C for descriptions of Geological Types.)

Quality Indicators

	If blank, no known limitations present
C	Clay and/or silt (fines) present in objectionable quantities
L	Deleterious lithologies present
O	Oversize particles or fragments present in objectionable quantities
-	Requires investigation

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.
Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.
Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.
Selected drilling data from the Ontario Ministry of the Environment and the Petroleum Resources Section, Ontario Ministry of Natural Resources.

Geology by W.R. Cowan, 1972
D.F. Hewitt, 1972
P.G. Telford, 1979

Compilation and drafting by R.M. Srivastava and G.S. Bell

Issued 1980

This map is published with the permission of E.G. Pye, Director, Ontario Geological Survey.
This map is to accompany O.G.S. Aggregate Resources Inventory Paper 8.

BRANTFORD

PARIS
BRANTFORD
WEST BRANTFORD
SOUTH DUMPFRIES TP
BRANTFORD TP
Osborne Corners
Governors Road
Brantford Airport 815'
Mount Vernon
Falkland
Wyndham Hills
Golf Course
Under Construction
Trans Station
Sports Track
Poultry Farm
Orchard
Orchards
Silos
Theatre
Motel
Factory
Brick Yard
Filtration Plant
Reservoir
Gravel Pits
Kilns
Abattoir
Greenhouse
Cemetery
Sawmill
City Limits
Underground Res
Pumping Station
Transformer Station
Radio Towers
Glade Farm
IR 40
Mohawk Indian Inst
Historic Site
Sewage Plant
Dump
Arena
Park
Golf
Hosp
Chy
Motel
Trans Sta
Pk
GP
C.N.R.
RIVER GRAND
THE OXBOW
BURFORD

BRANTFORD
WEST BRANTFORD
Cainsville
Langford
SOUTH DUMFRIES TP
BRANTFORD TP
BRANT CO.
ANCASTER TP
BRANTFORD TP
BRANTFORD TP
ONONDAGA TP
Osborne Corners
Orchard Road
Orchard Governors
Campsite
Paris Road
Factory
Windham Hills Golf Course
Golf Course
Under Construction
Trans Station
Theatre
Poultry Farm
Orchards
Silos
Sports Track
Radio Towers
Pumping Station
Radio 150
Transformer Station
Golf Course
Hospital
City Hall
Underground Res
Kerby Centre
Glebe Park
IR 40
Mohawk Indian Inst
Historic Site
Sewage Plant
Dump
Power Line
IR 40
Pumping Sta
Sawmill
Cemetery
Home for the Aged
City Limits
Motel
Auto Wrecker
Fur Farm
Cablevision
Gravel Pit
Turf Farm
Arena
C.N.I.B.
Water
Park
Orchard
Kilns
Pumping Station
Fairchild
Brantford Creek
THE OXBOW
RIVER
ELECTRIC
I
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Ministry of Natural Resources

Ontario

Hon. James A.C. Auld
Minister

Dr. J.K. Reynolds
Deputy Minister

ONTARIO GEOLOGICAL SURVEY

AGGREGATE RESOURCES INVENTORY

BRANTFORD TOWNSHIP

BRANT COUNTY

MAP 2
SELECTED SAND AND GRAVEL RESOURCE AREAS

Scale: 1:50,000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 40P/1

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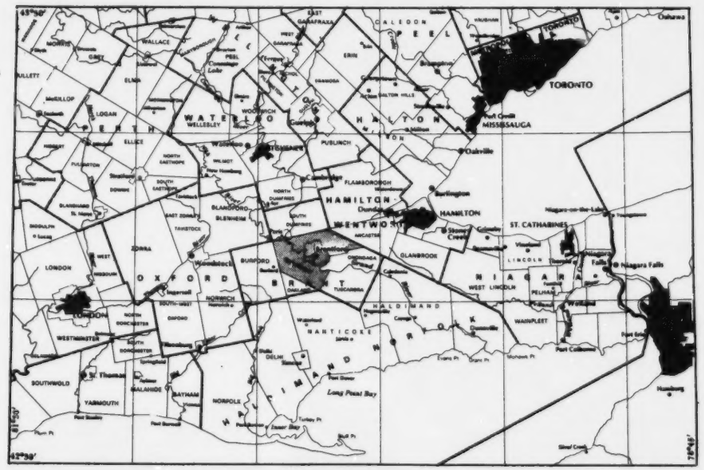


SYMBOLS

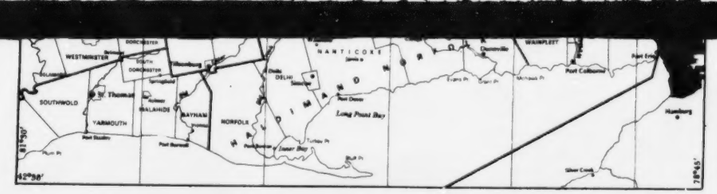
(Some symbols may not apply to this map)

- Geological and aggregate thickness boundary.
- Selected sand and gravel resource area; Primary significance; Deposit number: see Table 3.
- Selected sand and gravel resource area; Secondary significance.
- Selected sand and gravel resource area; Tertiary significance.
- Licenced property boundary; Property number: see Table 2.
- Unlicenced sand or gravel pit; Property number: See Table 2.

Abattoir
Orchards
Brantford Airport 815'
WEST BRANTFORD
City Limits
Home for the Aged
Underground Res
Kiln
Factory
Theatre
Greenhouse
Mount Vernon
Pumping Station
Cemetery
Sawmill
Park
Glebe Farm IR 40
Mohawk Indian Inst
Hosp
Historic Site
Pumping Sta
Sewage Plant
Dump
Mohawk
Chy 175'
Chy 150
Motel
Sports Track
Tile Plant
Newport
OXBOW
THR
BURFORD TP
Transformer Station
Gravel Pit
Mount Pleasant
Sluice Gate
Fur Farm
Burtch
Burtch Industrial Farm Reformatory
Chimney 135'
Abandoned Airfield
Radio Towers
Sewage
Qump
Auto Wrecker
BRANTFORD TP
OAKLAND TP
TUSCARORA TP
I
II
III
IV

WEST BRANTFORD
City Limits
Home for the Aged
Cemetery
Orchard
Kilns
Pumping Station
Park
Greenhouse
Tile Plant
Sports Track
Newport
Transformer Station
Orchards
Mount Pleasant
Sluice Gate
Fur Farm
Sewage
Burtch
Burtch Industrial Farm Reformatory
Chimney
Radio Towers
Abandoned Airfield
Dump
Auto Wrecker
BRANTFORD TP
OAKLAND TP
BRANTFORD TP
TUSCARORA TP
Cainsville
Catvision
Auto Wrecker
Fur Farm
BRANTFORD TP
ONONDAGA TP
Glade Farm
IR 40
Mohawk Indian Inst
Hosp
Historic Site
Sewage Plant
Pumping Sta
Motel
Sports Track
Water
Dump
Orchard
Paper Mill
City Limits
OXBOW
THE
Factory
Theatre
Turfa Farm
Underground Res
Keefer Stand
City Hall
Park
Pk
GP
N
I
II
III
IV
BRANT

BRANTFORD



SYMBOLS

(Some symbols may not apply to this map)

- Geological and aggregate thickness boundary.
- Selected sand and gravel resource area; Primary significance; Deposit number: see Table 3.
- Selected sand and gravel resource area; Secondary significance.
- Selected sand and gravel resource area; Tertiary significance.
- 2 Licenced property boundary; Property number: see Table 2.
- 4 Unlicenced sand or gravel pit; Property number: See Table 2.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.
Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.
Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.
Selected drilling data from the Ontario Ministry of the Environment and the Petroleum Resources Section, Ontario Ministry of Natural Resources.

Geology by W.R. Cowan, 1972
D.F. Hewitt, 1972
P.G. Telford, 1979

Compilation and drafting by R.M. Srivastava

Issued 1980

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This map is to accompany O.G.S. Aggregate Resources Inventory Paper 8.

PARIS
SALINA FORMATION
SOUTH DUMFRIES TP
BRANTFORD TP
Osborne Corners
Governors
Road
Brantford and Paris Road
Brick Yard
Park
Reservoir
Orchard
Filtration Plant
LAKE ERIE
Trans Station
Factory
Gravel Pits
Kilns
Falkland
Gas Pipeline (underground)
Boy Scout Camp
NORTHERN ELECTRIC
Res. Gravel Pit
Religious Camp
Abattoir
Orchards
Brantford Airport 815'
Transformer Station
Greenhouse
Mount Vernon
Bishopgate
BURFORD
Campsite
Golf Course
Wyndham Hills
Pumping Sta
Wool Plant
Theatre
Poultry Farm
Silos
Sports Track
Under Construction
Radio Towers
Arena
Mount Hope Cem
C.N.I.B.
Underground Res
Auto Wrecker
Transformer Station
Pumping Station
Radio
City Hall
Motel
Trans Sta
Glebe Farm IR 40B
Mohawk
Power Main
Dump
Sewage Plant
Historic Site
IR 40
Sawmill
Cemetery
Home for the Aged
City Limits
WEST BRANTFORD
BRANTFORD
OXBOW
RIVER
Fair
Cains

SALINA FORMATION
GUELPH FORMATION
BRANTFORD
WEST BRANTFORD
Cainsville
Langford
SOUTH DUMFRIES TP
BRANTFORD TP
BRANT CO.
ANCASTER TP
ONONDAGA TP
Osborne Corners
Orchard Road
Governors
Wyndham Hills
Golf Course
Paris Road
Under Construction
Trans Station
Theatre
Wool Plant
Poultry Farm
Orchards
Silos
Sports Track
Radio Towers
Fairchild
Gravel Pit
Pumping Sta
RIVER
C.N.I.B.
Arena
Mount Hope Cem
Auto Wrecker
Transformer Station
Pumping Station
Radio 150'
Golf Course
Underground Res
Glebe Farm IR 40B
Mohawk Indian Inst
Mohawk
Dump
Tower Hill
Sewage Plant
Historic Site
IR 40
City Limits
Home for the Aged
Cemetery
Sawmill
Park
OXBOW
THE
Creek
Brantford
Big
Water 135'
Cablevision 160'±
Fur Farm
Motel
Chy 138'
Chy 175'
Chy 150'
Sports Track
Trans Sta
Water
Orchard
Campsite
Golf Course
Pumping Station
Underground Res
Home for the Aged
Auto Wrecker

Ministry of Natural Resources

Ontario

Hon. James A.C. Auld
Minister

Dr. J.K. Reynolds
Deputy Minister

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

BRANTFORD TOWNSHIP
BRANT COUNTY

MAP 3
BEDROCK RESOURCES

Scale: 1:50,000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: **40P/1**

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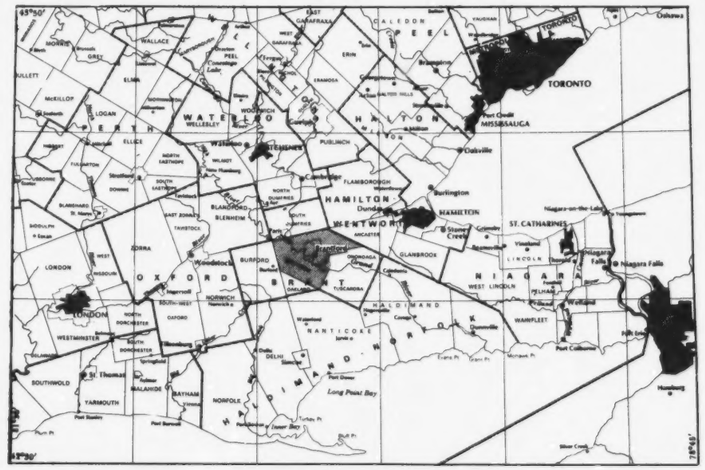


LEGEND

PALEOZOIC

SILURIAN

UPPER SILURIAN

SALINA FORMATION
Dolostone shale, gypsum, salt

MIDDLE AND LOWER SILURIAN

GUELPH FORMATION
Dolostone

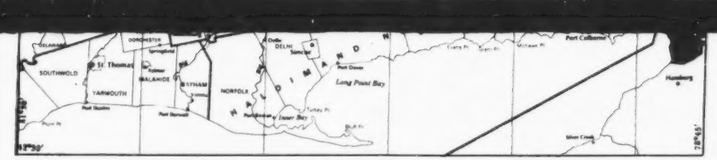
SYMBOLS

(Some symbols may not apply to this map.)

Geological boundary

Abattoir
Orchards
Kilns
Brantford Airport 815'
Transformer Station
Factory
Theatre
Turf Farm
WEST BRANTFORD
City Limits
Home for the Aged
Underground Res
Trans Sta
Glebe Farm IR 40B
Mohawk Indian Inst
Hosp
Historic Site
Pumping Sta
Sewage Plant
Dump
IR 40
Sawmill
Cemetery
Museum
Tile Plant
Newport
Sports Track
Mount Vernon
Bishopgate
Reservoir
Greenhouse
Pumping Station
Gravel Pit
BRANTFORD TP
BURFORD TP
SALINA FORMATION
Mount Pleasant
Sluice Gate
OAKLAND TP
TUSCARORA TP
THE OXBOW
Burtch Industrial Farm Reformatory
Burtch
Chimney
Abandoned Airfield
Radio Towers
Auto Wrecker
Park
Orchard
Orchards
Gravel Pit
Fur Farm
Sewage
Dump
Motel
Golf Course
Mohawk
Pipe Line
Power Line
City Limits
Transformer Station
Kilns
Reservoir
Greenhouse
Factory
Sports Track
Tile Plant
Museum
Cemetery
Sawmill
Pumping Station
Pumping Sta
Hosp
Motel
Golf Course
Underground Res
Chimney
Abandoned Airfield
Radio Towers
Auto Wrecker
Dump
Sewage
Fur Farm
Sluice Gate
Gravel Pit
Transformer Station
Kilns
Park
Orchard
Orchards
Factory
Theatre
Reservoir
Greenhouse
Pumping Station
Museum
Cemetery
Sawmill

WEST BRANTFORD
City Limits
Home for the Aged
Cemetery
Orchard
Park
Museum
Underground Res.
Kerby Grand
City Park
Trans Sta
Glebe Farm IR 40B
Sports Track
Motel
Mohawk
Dump
Power Mill
Chy 175
Chy 150
Mohawk Indian Inst
Hosp
Sewage Plant
Historic Site
Pumping Sta
IR 40
Sawmill
City Limits
THE OXBOW
Cainsville
Cablevision 160±
Auto Wrecker
Fur Farm
BRANTFORD TP
ONONDAGA TP
SALINA FORMATION
Greenhouse
Tile Plant
Newport
Transformer Station
Orchards
Mount Pleasant
Sluice Gate
Kilns
Fur Farm
Sewage
Burtch Industrial Farm Reformatory
Burtch
Chimney 135'
Abandoned Airfield
Radio Towers
Pump
Auto Wrecker
BRANTFORD TP
TUSCARORA TP
I
II
III
IV
N
BRANTFORD



LEGEND

PALEOZOIC

SILURIAN

UPPER SILURIAN

SALINA FORMATION
Dolostone shale, gypsum, salt

MIDDLE AND LOWER SILURIAN

GUELPH FORMATION
Dolostone

SYMBOLS

(Some symbols may not apply to this map.)

- Geological boundary.
- 25 — Drift thickness contour line (25 foot (8 m) interval).
- x — Isolated bedrock outcrop.
- Bedrock within 3 feet (1 m) of surface: see Table 4.
- Bedrock covered by 3 to 25 feet (1 m to 8 m) of overburden: see Table 4.
- Bedrock covered by 25 to 50 feet (8 m to 15 m) of overburden: see Table 4.
- (1) Selected bedrock resource area; Deposit number: see Table 6.
- 2 — Licenced quarry boundary; Property number: See Table 5.
- ● Q4 — Unlicenced quarry; Property number; See Table 5.
- O 27 — Selected drilling location indicating reported depth to bedrock (in feet).

SOURCES OF INFORMATION

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BRANTFORD